Department of Defense Energy Security Initiatives

Prepared by the DoD Energy Security Task Force
Office of the Under Secretary of Defense (Acquisition, Technology, and Logistics)

INTRODUCTION

Energy is a strategic resource that has significant security, economic, geo-strategic and environmental implications for the nation and important operational implications for the Department of Defense (DoD). The focus of the DoD, like much of the nation, is to reduce demand through culture change and increased efficiency. The DoD is undertaking numerous initiatives and activities to promote energy savings and energy efficiency across the Department. This article presents an overview of some of these efforts.

> "We will always field the finest fighting force in the world ... but that force is extraordinarily energy dependent ... and unfortunately, we may be learning the wrong lessons in the Middle East where fuel is readily available. We need alternative solutions."
>
> Former Deputy Secretary of Defense, Gordon England

ENERGY IS A LIMITING FACTOR

The intensity of day-to-day fuel demand in Iraq and Afghanistan is greater than in any war in history. In fiscal year (FY) 2007, The DoD's total energy costs exceeded $13 billion, and an additional $5 billion was requested in FY 2008 to cover increased fuel costs.

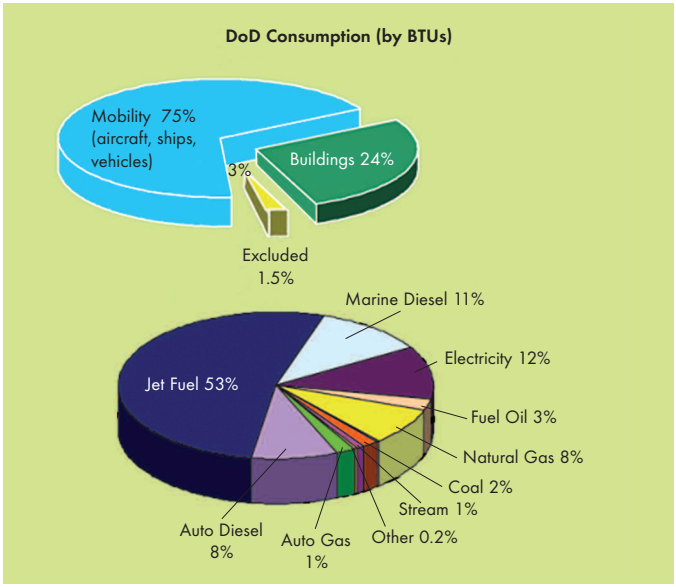

Figure 1. DoD FY07 energy consumption.

Figure 1 shows a breakdown of DoD energy consumption in FY07. Logistics convoys along vulnerable lines of communication are prime targets for insurgent forces. Protecting these convoys imposes a high burden on combat forces by diverting combat units from direct engagement to force protection missions. The strategic importance of energy security is well appreciated by decision-makers. However, energy is also tactically relevant as exemplified during Operations Iraqi Freedom and Enduring Freedom, and field commanders are looking to the Department and Services to provide battlefield solutions that reduce vulnerability while increasing capability.

From a tactical or operational perspective, reducing fuel demand can remove convoys from the battlespace, reduce operational vulnerability, and free combat forces for other missions. More efficient combat and combat-related systems inherently have greater endurance, extending the battlespace by enabling forces to travel longer distances and remain concealed longer without refueling. From the Departmental force planning perspective, greater energy efficiency in the force provides the option of either reducing the size of the fuel logistics force structure (move people and investment from the "tail" to the "tooth"), or maintaining more reserve logistics capacity to reduce future operational risks. Finally, greater fuel efficiency in the force reduces direct operating costs, mitigating the budget effects caused by commodity price volatility.

Fully Burdened Cost of Fuel

In 2001, a Defense Science Board (DSB) task force estimated the minimum cost of delivering over-land fuel in a combat zone to be $15 per gallon without including force protection, and the cost of delivering a gallon of fuel through an airborne tanker at $26 (excluding the cost of buying the aircraft). These estimates were based on a commodity price at the time of less than ninety cents per gallon for fuel. In 2006, the JASON* Defense advisory group estimated the cost of delivering a gallon of fuel via an airborne

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14. ABSTRACT
Energy is a strategic resource that has significant security, economic, geo-strategic and environmental implications for the nation and important operational implications for the Department of Defense (DoD). The focus of the DoD, like much of the nation, is to reduce demand through culture change and increased efficiency. The DoD is undertaking numerous initiatives and activities to promote energy savings and energy efficiency across the Department. This article presents an overview of some of these efforts.

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tanker, including a small proportion of the cost of the aircraft, at approximately $42 per gallon. The term coined to capture this more realistic cost of delivered fuel in theater is *fully burdened cost of fuel* (FBCF). The FBCF (vice fuel-only costs) will be used as part of the cost analysis conducted for new acquisition programs, as well as in retrofit, reconstitution, or upgrades that are being considered. Efforts are currently underway to more accurately quantify FBCF for various types of systems in a range of appropriate scenarios. This will support both smarter force planning and technology development investment.

Defense Energy Security Task Force

In May 2006, the Secretary of Defense commissioned the Director, Defense Research and Engineering to chair the Energy Security Task Force (ESTF) to define an actionable investment roadmap for lowering DoD's fossil fuel requirements and developing alternate fuels for use by the Department. The ESTF is comprised of senior leaders from across the Department with a stake in energy, including: requirements development, technology, acquisition, logistics, installations and environment, policy, and the budget. By taking a systems approach, integrating different functional areas, the indirect and potentially negative unintended consequences of various courses of action can be better understood, thereby improving decision making for the Department.

Underscoring the importance of energy to the Department, the Secretary of Defense designated Energy Initiatives as one of the Department's Top 25 Transformational Priorities, and the military departments have established energy leads and task forces, responsible for overseeing all energy efforts. The DoD is currently working to better understand the value of energy in terms of cost and operational capability, and to modify business processes to more accurately integrate those values into decisions that affect requirements planning, acquisition and funding priorities.

ENERGY SECURITY INITIATIVES AND ACCOMPLISHMENTS

The DoD is actively focused on initiatives to reduce energy demand, increase alternative sources of energy, and ensure the energy is delivered reliably and efficiently. Although the DoD's emphasis is on addressing energy security, many of these initiatives may also benefit the environment through increased production of renewable energy, improved use of resources and disposal of waste products, and reduced greenhouse gas emissions.

DoD Energy Security Strategic Plan

To provide a coherent direction across the spectrum of energy issues, the ESTF is finalizing a DoD-wide Energy Security Strategic Plan to address the issues and focus the myriad energy organizations that control and are impacted by energy variables. The plan will establish actionable policies, practices and metrics, and will require accountability to secure enterprise-wide buy-in.

The ESTF assessed energy consumption of platforms and facilities, identified the largest energy users, and developed an overarching strategy that addresses six functional areas:

- Fuel Optimization for Mobility Platforms
- Operational Efficiencies/Optimization and Commercial Practices
- Facility Energy Initiatives
- Domestic Energy Supply and Distribution
- Tactical Power Systems and Generators
- Geopolitical Considerations

The Energy Security Strategic Plan lays out four higher level goals that cut across these functional areas and describe a desired future state for the Department with respect to energy.

1. Reduce Demand
2. Assure Supply
3. Improve Processes
4. Establish and Monitor Energy Metrics

Goal 1: Reduce Demand

In order to enhance mission effectiveness, the systemic demand for fuel from DoD platforms, weapons, and fixed and tactical installations must be reduced. The DoD is exploring and implementing technologies that would reduce energy consumption. The installations community has made significant progress in reducing energy consumption (over 30% since 1985). In FY 2007, the Department reduced energy usage by over 10% from the 2003 baseline and has a mandate to continue reducing consumption by three percent per year through 2015. This will be accomplished through a variety of technologies such as sustainable design, which will reduce life cycle costs. For platforms, efforts cover a variety of technical areas, including lightweight materials and armor, novel structural shapes and more efficient powerplants (engines, motors, power storage, etc.), to identify ways to reduce fuel consumption affordably and sustainably, while sustaining (or enhancing) operational capability.

Facilities

The DoD established an Executive Committee, led by the Deputy Under Secretary of Defense for Installations and Environment, to address the goals set forth in recent federal energy guidance, including the Energy Policy Act of 2005, Executive Order 13423: "Strengthening Federal Environmental, Energy, and Transportation Management" and the Energy Independence and Security Act of 2007. The Executive Committee is coordinating and prioritizing these initiatives and is serving as a conduit to the Energy Security Task Force for installation and environmental energy issues.

Net-Zero Plus Initiative at the National Training Center (NTC), Fort Irwin, California. NTC is currently exploring the feasibility of removing their facilities completely from the electric grid and could have the potential to sell "green" energy back to the California grid. The Army has named Fort Irwin as a Net-Zero Plus Installation.

Efficient technologies for housing demonstration, Fort Belvoir, Virginia. The Power Surety Task Force and the Army's Rapid Equipping Force are demonstrating spray foam insulation (see Figure 2) and a solar power and storage system in Fort Belvoir housing. The Fort Belvoir demonstration includes a "control" case (with no new energy technologies) and will test the effectiveness of several technologies in three additional houses, each with successively more energy technologies. This $115,000 demonstration will provide data to determine the most cost effective combination of insulation and solar cells.

Pentagon Wedge 5 Renovation.† The Pentagon Renovations office has approved the use of LED light fixtures in place of the fluorescent and other lights used in the previous renovated

Figure 2. Installing foam insulation on houses at Ft. Belvoir.

wedges. The effort involves 4,200 light fixtures, each of which uses approximately 20 W less energy, yielding a total energy savings of 376,000 kWh/year (i.e., for one-fifth of the Pentagon). The fixtures are expected to last about 11.5 years, resulting in a net savings of about $4 million over the life of the fixtures.

Platforms

Fuel efficiency for turbine engines. The Highly Efficient Embedded Turbine Engine (HEETE) initiative, part of the Versatile Affordable Advanced Turbine Engine (VAATE) program, is developing high-pressure ratio, high temperature core technology, with the potential to reduce specific fuel consumption up to 25% over current systems. HEETE is addressing the highest technical risk element in new engine development – the high pressure compressor component development. The current schedule includes a rig test in FY 2010, demonstrating a technology readiness level of four or five in a laboratory or relevant environment. These technologies are applicable to all turbine engines and could be used in commercial aircraft.

Efficient engines for Unmanned Aerial Vehicles (UAVs) and generators. The Small Heavy Fueled Engine demonstration is a three year program, initiated in FY 2008, and is anticipated to increase fuel efficiency and power density by 20% for UAVs and generators. The three engines assessed in the demonstration will operate on heavy fuels such as JP-8, thereby reducing the number of different fuels used on the battlefield and reducing the strain on the logistics tail.

Testing fuel efficient equipment on ground vehicles. The Fuel Efficient Demonstrator (FED) is testing the feasibility and affordability of achieving significant decreases in fuel consumption in a tactical vehicle, without sacrificing the performance or capability. This program is integrating potentially high-payoff fuel efficient technologies, like efficient propulsion and drivelines, and advanced lightweight materials in new and innovative designs. Successful technologies may be incorporated in future procurements for the Joint Light Tactical Vehicle (JLTV).

Diesel hybrid vehicle testing. The Department is testing various diesel hybrid vehicles (see Figure 3). Hickam Air Force base is testing a plug-in parallel hybrid drive system to be integrated into a step van that will provide improved efficiency, superior performance and greater fuel economy. The system design consists of a 2.5 liter/75 kilowatt (kW) diesel engine, a 97 kW AC induction motor, and a continuous variable transmission. The Air Force is also testing and demonstrating Heavy Duty Hybrid Electric Class 8 Mack Trucks, with an Integrated Starter Alternator Motor which assists the diesel engine to provide power to the drive train. The trucks are being used by the Civil Engineering and Aircraft Refueling activities.

Extended range UAVs. The Air Force completed a preliminary design review for a prototype long endurance UAV to fly medium altitude missions un-refueled for five to seven days. The intent of this demonstration was to provide for affordable persistent surveillance using the latest energy efficient aviation technologies. Although the preliminary design review found the budget was insufficient to build and demonstrate a flying prototype, insights from this program may be integrated into other ongoing UAV programs, including the Army's Orion program.

Figure 3. Diesel hybrid vehicle testing at Hickam AFB.

To provide extended intelligence, surveillance and reconnaissance mission capability, the Naval Research Laboratory (NRL) is developing a fuel cell powered UAV with a projected endurance exceeding 24 hours operation on hydrogen gas. The UAV and fuel cell are being designed as an integrated package, and the project is planned for completion in 2009.

There are also two Joint Capability Technology Demonstration (JCTD) programs investigating even longer flight times. The Global Observer JCTD will demonstrate a liquid hydrogen powered unmanned aerial vehicle, using a modified, off-the-shelf internal combustion engine, capable of flying extremely long endurance, up to 7 days, with a moderately sized payload capacity at an altitude of 55-65,000 ft. The Zephyr JCTD will demonstrate and transition into service a solar-powered unmanned aerial vehicle capable of flying continuous operations for months at a time using solar power plus batteries for continual day/night operations.

Operational Efficiencies

The ESTF is working with the Combatant Commanders to understand their energy needs and concerns, which vary in priority among the different commands. For example, Central Command is primarily concerned with the dangers of inefficient fuel movement to forward operating bases, while the European Command is focused on the security aspects associated with energy suppliers using energy as a way to exert influence over other nations. The newly formed Africa Command is looking for sustainable energy capabilities for security cooperation to enable power generation or fuel generation in remote and/or austere environments.

The Power Surety Task Force (PSTF), formerly part of the Army's Rapid Equipping Force (REF), has been transferred to the ESTF, and one of their primary roles is to serve as a liaison with the Combatant Commanders and provide support for energy considerations. The PSTF has tested a variety of new energy technologies that can be used in theater. Their process of first reducing demand, then conducting an engineering assessment to remove wasteful generation or excess capacity, and finally, supplementing with alternative and renewable energy, will enable forward bases and other installations to set the foundation for optimizing energy use in the long-term.

In an effort to demonstrate the operational efficacy of demand reduction coupled with alternative/renewable power, the PSTF and the NTC installed energy efficient structures (domes, spray-foam insulation, renewable power generator, and efficient heat-

Figure 4. Monolithic dome and renewable energy generator at NTC.

ing, ventilating, and air conditioning systems) in the training area (see Figure 4). These structures demonstrate a holistic approach that can provide an estimated energy savings of about 60%. This proof of concept effort was intended to make forward operating bases energy independent for power generation.

In July 2007, the PSTF and REF demonstrated a technique for insulating temporary structures, such as tents and containerized living units, using an exterior application of spray foam. The resulting energy savings of 40-75% led Multi-National Force Iraq to award a $95 million contract to insulate nine million square feet of temporary structures. Based on extrapolated data from previous demonstrations, the additional nine million square feet of insulated temporary structures could save more than 77,000 gallons of fuel per day in theater, equivalent to about 13 truckloads of fuel, with associated cost savings of over $300,000 per day at $4 per gallon (not including the military logistics and force protection saved from the demand reduction).

Increased use of simulators for training. Preliminary studies have indicated that the increased use of simulators could potentially yield significant savings, resulting from reduced fuel costs, maintenance, and platform "wear & tear". The Joint Staff is leading a study to assess current simulator usage, develop a cost model for the business case supporting greater simulator use, and determine the feasibility of substituting additional simulator time for live training without decreasing operational capability.

Goal 2: Assure Supply

The DoD must minimize risk in energy availability, accessibility and distribution to military operations while sustaining operational capability. In addition to improving combat unit capability (by reducing dependence on its fuel tail), some technical solutions for reducing platform fuel demand show promise for increasing individual capability as well. The DoD is shifting reliance toward alternative and renewable sources of energy, thereby reducing dependence on non-assured sources of oil.

Renewable Energy

In FY 2007, the DoD reduced energy usage by over 10% from the 2003 baseline and almost 12% of the electricity was generated from renewable energy sources. The DoD is increasing use of "traditional" renewable energy sources (e.g., solar, wind, etc.) and is also exploring new technologies, such as ocean and wave harvesting.

Figure 5. Nellis Air Force Base solar array.

Solar power. Solar power is the largest contributor in the Air Force's renewable energy development program. In December 2007, the Air Force commissioned the largest photovoltaic solar array in the Americas (14.2 megawatts) at Nellis Air Force Base (see Figure 5). This supports about one fourth of the base's energy usage per day and has an estimated annual cost savings of $1 million. In 2007, the Air Force continued to lead the federal government in green power purchases, with 37 bases meeting some portion of their base-wide electrical requirements from commercial sources of wind, solar, geothermal, or biomass. Additional solar projects on underutilized land are planned using the enhanced used lease authority.

Geothermal power. The Navy has made good use of the authority in 10 U.S.C. 2922a to receive revenues from geothermal power facilities, as they have done with the development of the 270 megawatt plant at China Lake, California in the 1980s that provides enough power to supply electricity to 180,000 homes. The Navy recently awarded a contract to build a 30+ megawatt geothermal plant at Fallon Naval Air Station, Nevada, and the Department is looking at other opportunities for similar public/private ventures. The Department is exploring the feasibility of expanding the Title 10 authority to enable DoD to receive revenue from other energy resources on its lands. Ground source heat pumps are increasingly being used, particularly at housing units. For example, Offutt AFB has installed 1,131 tons of ground source heat pumps for its dorms.

Testing other potential energy generation technologies. The Navy is testing other energy sources for their feasibility to produce energy cost effectively. The Navy installed the first wave power buoy at Marine Corps Base Kaneohe Bay, Hawaii, and is partnering with industry to test a second buoy. In addition, the Navy is contracting with a commercial firm to provide a technology demonstration of tidal energy harvesting in the Puget Sound area. The Navy also is partnering with the British Government to design and install a barge mounted off-shore Ocean Thermal Energy Conversion (OTEC) plant for electrical and water requirements at Diego Garcia.

Solar roofs. Thin-film solar panels are being used increasingly by the Department. Naval Base Ventura County installed an 87 kW rooftop amorphous silicon thin-film photovoltaic (PV) laminate system on a building in Port Hueneme, California, and the Navy also installed photovoltaic parking garages at Naval Base Coronado (see Figure 6), North Island, California, producing one megawatt of power. The Defense Commissary Agency initiated installation of a roof mounted, PV array capable of producing an estimated 152 kW at the Los Angeles AFB Commissary in California.

Figure 6. Photovoltaic parking garage at Naval Base Coronado, North Island, California.

Alternative Fuels/Energy Sources

The Department is pursuing a variety of efforts in alternative fuels, primarily focused on testing and certification, enabling our systems to use different fuels regardless of the feedstock or production method. We already rely on local fuel sources in theater, like Jet A-1 (commercial jet fuel) in Europe, which differs slightly from JP-8. Efforts include improving the combustion process of engines using alternative fuels, optimizing fuel composition, understanding the equipment and systems impacts of alternative fuel use, such as corrosion and wear, and establishing protocols for alternative fuels qualification in aircraft, ships, vehicles and generators.

Synthetic fuel (synfuel) certification. Several efforts by the Services are underway to test and certify synfuels on both aircraft, ground vehicles, and support equipment. For example, in August 2007, the Air Force certified the B-52 to use a 50/50 blend of synthetic fuel and conventional aviation fuel. They have since certified the B-1 and C-17 (see Figure 7). Tests are underway to certify the F-15 and F-22 in the near future, with an objective to certify the entire Air Force fleet by early 2011. The Air Force has a goal to cost-effectively acquire 50% of its continental US aviation fuel via a synthetic fuel blend utilizing domestic feedstocks and produced in the US by 2016, with the intent to require that the synthetic fuel purchases be sourced from suppliers with manufacturing facilities that engage in carbon dioxide capture and effective reuse resulting in the use of fuels that have a "greener" life cycle environmental foot print the petroleum-derived products.

Figure 7. C-17 transcontinental flight using a synfuel blend.

The Air Force is developing an Assured Aerospace Fuels Research Facility to support the study and evaluation of how processing and upgrading operations, conditions, and catalysts impacts the production, characteristics, quality, and carbon dioxide (CO_2) footprint of jet fuel made from alternative sources. Joint studies sponsored by the Air Force and the Department of Energy (DOE) show potential life cycle CO_2 reductions below that of conventional petroleum if waste biomass is combined with coal to produce aviation fuels via Fischer-Tropsch (FT) processing. This facility will enable the Air Force to conduct a comprehensive analysis of the potential that biomass may offer to reduce the life cycle CO_2 footprint of FT technology. Looking beyond FT fuels, the Air Force, in partnership with DARPA and industry, is investigating the suitability of second and third generation biomass-derived transportation fuels (e.g., cellulosic biomass, algae oils, animal fats, etc.) as renewable feedstock options for aviation use.

The Navy is conducting research on the effective use of alternative logistics fuels in naval power systems. These efforts include addressing the impacts these fuels have on engine internals and fuel distribution system components, optimizing fuel composition and improving the combustion process. The Navy also is establishing protocols for alternative fuel qualification for use on naval vessels and aircraft. In addition, the Army is testing a wide range of alternative fuels at the Army Research, Design, and Engineering Command in Warren, Michigan.

The Services and the Defense Energy Support Center are also working closely with the Commercial Aviation Alternative Fuels Initiative that represents the airlines, airports, and manufacturers to efficiently and economically certify the commercial airline fleet. This effort builds on the fact that many aircraft in the commercial and military fleets share common platforms, systems and engines.

Investment in biofuels. Commercially available biofuels are in limited supply and have lower energy density than their petroleum-based equivalent. Research suggests that some bio-based feedstocks could be converted into hydrocarbon fuels efficiently and affordably. Since the military's primary fuel source is jet fuel, DARPA is demonstrating the ability for oil rich crops, such as algae, cuphea and jatropha, to create JP-8 at energy density levels sufficient to power military systems.

Carbon capture and reuse. In FY 2007, the Air Force and the Office of the Secretary of Defense collaborated with the Department of Energy's National Energy Technology Laboratory (NETL) and Arizona Public Service in a program to develop a method to use algae to reuse CO_2. The work involves development of an algae-based CO_2 absorption system which produces algae oils that can be further developed into jet fuel. The Air Force helped develop the establishment of a laboratory at Arizona Public Service to study this algae oil-to-jet fuel process.

Biodiesel life extension program (O28 O2Diesel™). Military vehicles can experience mechanical problems when using standard biodiesel, as stagnant biodiesel develops microbial growth leading to contamination and degradation. The Air Force is completing a $5 million demonstration with an ethanol/bio-diesel fuel blend (7% ethanol/20% pure biodiesel), with tests conducted on numerous vehicles in a variety of different climates. The new blend (O28 O2Diesel™)‡ eliminates and prevents the contamination while reducing particulate matter emissions by up to 80%. In addition, the Navy is constructing a biodiesel production facility to further prove the feasibility of using cooking oil to produce fuel.

Hydrogen technology testing. The Air Force Advanced Power Technology Office (APTO) is conducting hydrogen technology and capability demonstrations at Hickam AFB. (This effort is described in the article by Thomas Quinn in this issue.)

The Navy is continuing a hydrogen fuel station and non-tactical fuel cell vehicle (FCV) demonstration at Camp Pendleton Marine Corps Base, California. This effort is an Environmental Security Technology Certification Program (ESTCP) project to demonstrate and validate an on-site steam methane reformer for hydrogen production. The project successfully completed demonstrations with a General Motors (GM) hydrogen fuel cell pick-up truck and sports utility vehicle in FYs 2006 and 2007, and will lease three GM FCVs to demonstrate extended vehicle range capability and to provide fuel cell test data in support of potential naval electric ship applications.

Waste-to–energy systems. The Air Force APTO is working to integrate a waste-to-energy system at Eielson Air Force Base, Alaska (see Figure 8). This system will be an advanced gasification-based core technology with the capacity to convert 10 to 50 tons per day of a wide variety of waste materials into 1 megawatt of clean electricity, to be used on-site by the base, thereby reducing the amount of electricity purchased from the local grid. This will reduce energy costs and improve the security of the base, enabling the base to use onsite sources to produce renewable energy, independent of the local grid. In a rapid-deployment scenario, the technology can help the Air Force reduce the use of imported fuels at installations in the short term. Waste-to-energy systems provide a tool for achieving both the renewable energy and landfill avoidance goals established by Executive Order 13423.

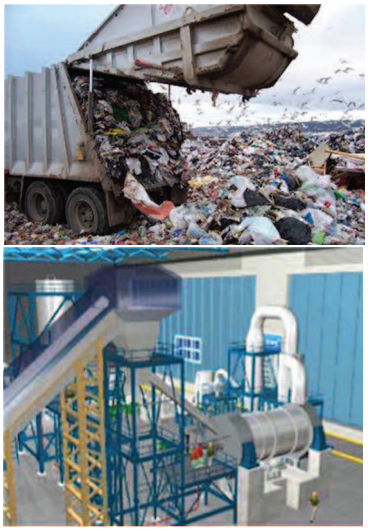

Figure 8. Waste to energy technologies, Eielson, AFB.

Very high efficiency solar cells. DARPA demonstrated breakthrough conversion efficiency with a set of solar cells (over 42%) and is currently using this set in a proof-of-concept solar power module with an objective of 40% efficiency, which would be almost double that of current solar power modules. The end-of-program goal is to achieve 50% efficiency affordably at the module level. The DARPA module is using a novel lateral cell design that will be optimized in spectrally split band gaps (high, medium-high and low). If successful, this could be a game changer, making solar energy cost effective.

Nuclear Energy Initiative. The Air Force was asked by several members of the US Senate to determine if Air Force bases could be appropriate siting locations for small package nuclear power generation facilities. The Air Force issued a request for information (RFI) to gauge industry's interest in the concept, and to solicit their ideas on potential technologies, financing options, and other aspects of a potential project. The Air Force model is for this completely commercially driven. The Air Force will not build, own, operate, or license a nuclear power plant. The goal is to provide a suitable site, and as a customer and market leader, provide the opportunity for the private sector to build and operate the plant, using an enhanced use lease (EUL), or similar, authority.

Tactical Power Systems and Generators

Transportable Hybrid Electric Power Stations (THEPS). The REF completed testing of Transportable Hybrid Electric Power Stations. These devices were requested by Major General Zilmer, Operational Commander in the Al-Anbar province in Iraq, in response to the vulnerability of US Forces while delivering fuel. Although significant fuel savings were found, the systems were not robust enough for a forward operating base environment. However, insights from this effort were used to advance the Hybrid Intelligent Power program.

Hybrid Intelligent Power (HI-Power) generator. The HI-Power program is a revolutionary effort that will develop and validate a DoD standard tactical intelligent power management architecture (see Figure 9) that incorporates source management (including the use of renewable energy sources where applicable), energy storage technologies, power distribution, and demand management.

Solutions currently being pursued include the development of active distribution networks and intelligent, automated hybrid power systems. Power management and distribution techniques will enable maximum power utilization with a high degree of efficiency for use with various mobile and portable applications in the 2 to 500 kW range.

Figure 9. Hi-Power generator at Ft. Belvoir, VA.

This power management architecture will include small and medium sized tactical versions for mobile forces and larger transportable systems appropriate for forward operating bases. Initial models estimate fuel savings of up to 40% compared to current systems, reduced maintenance and personnel requirements, and fewer power interruptions. The resulting architecture will impose minimum impacts on transportability, deployability, and readiness levels of current and upcoming platforms.

Tactical Garbage to Energy Refinery (TGER). The REF has deployed two TGERs to Iraq for a capability demonstration and evaluation. TGER, shown in Figure 10, converts field waste (paper, plastic, cardboard and food slop) into biofuel that is used

to power a 60 kW generator. A battalion sized forward operating base (600-800 soldiers) creates about one ton of garbage per day that can be recycled into energy, so the system is designed to convert one ton of waste into energy equal to about 100 gallons of JP-8. It is skid mounted and deployable on a military 5-ton flatbed trailer.

Figure 10. Tactical Garbage to Energy Refinery (TGER).

Solid Oxide Fuel Cells. The Navy and Army are developing and demonstrating compact and mobile 10 kW high-temperature fuel cells to power critical equipment, including GPS, radio and communications equipment, computers, intelligence, surveillance and reconnaissance gear, and laser designators. These systems provide silent, portable power and eliminate dependence on large generator or grid power for battery charging. These fuel cells are demonstrating a high efficiency (approximately 55%) and are being designed to be compatible with kerosene-based jet fuels such as JP-5 and JP-8. They provide low weight for the available energy content to the warfighter carrying them. Additionally, they will provide auxiliary power for applications on vehicles for missions over 24 hours.

Remote Site Tactical Hybrid Power. The 3rd Brigade, 1st Armored Division in Iraq, used excess electricity generated from his Forward Operating Base (Camp Taji) to provide power to the local Iraqi population as part of his engagement strategy to facilitate better community relations. This resulted in enhanced security for local population, enhanced security for coalition forces and created a safe and secure environment through a more cooperative relationship with the local population.

Expanding on this success, the REF has selected a vendor to deploy a hybrid generator (wind, solar, battery storage, back-up diesel) for US Forces at a Kuwaiti border crossing communications site, based on an assessment by the Power Surety Task Force. The intent of this effort is to demonstrate the efficacy of commercial hybrid power stations in meeting military needs in isolated, but fixed locations.

Goal 3: Improve Processes

Properly valuing energy in acquisition decisions will aid in reducing life-cycle operation and sustainment costs, thereby dampening price fluctuation impacts on the Department. Opportunities to leverage efforts by other organizations, such as federal agencies, industry, academia, and the international community, are also being identified. In addition, the DoD is evaluating the strategic and operational implications of global energy economics and associated security issues, including where a global energy supplier has the ability to exert influence over its consumers. The Department also wants to retain its role as a good environmental steward, remaining cognizant of potential environmental impacts and how our actions may be perceived in the globally. The Department has made progress to incorporate energy considerations in its planning and business processes.

Requirements Generation and Acquisition

Energy in the requirements development process. In August 2006, the Vice Chairman of the Joint Chiefs of Staff signed a memorandum establishing the requirement for an energy-related Key Performance Parameter (KPP) for new acquisition programs to be selectively applied. KPPs are attributes or characteristics of a system that are considered critical or essential to the development of an effective military capability. The methodology and procedures for establishing program-relevant energy KPPs are under development. In May 2007, the Joint Staff updated their directives[§] to require use of KPPs as established in the Vice Chairman's memo. The energy efficiency KPP requires life-cycle cost analysis to include the burdened cost of fuel in the Analysis of Alternatives (AoA) and/or Evaluation of Alternatives (EoA) and subsequent analyses and acquisition program design trades. In such analyses, the fully burdened cost of fuel is defined as the price of the fuel, plus its delivery chain and force protection requirements, all taken from a range of the applicable defense planning scenarios. This scenario-based force planning methodology will underpin both the KPP within the DoD requirements process (Joint Capabilities Integration and Development Process (JCIDS)) and the calculation of the fully burdened cost of fuel in acquisition.

Energy in the acquisition process. The acquisition process is currently under revision to more accurately value energy. In April 2007, the Under Secretary of Defense (Acquisition, Technology and Logistics) signed a policy memorandum to use the fully burdened cost of fuel as a major basis for all trade analyses for acquisition programs. The memo also established three pilot programs (the Joint Light Tactical Vehicle (JLTV), alternative ship propulsion for the next generation cruiser (CG(X)) and the Next Generation Long Range Strike (Next Generation Bomber)) to validate the approach and to facilitate development of policies and procedures for how to apply it in the acquisition process. In December 2008, the DoD acquisition directive (5000.2) directed energy costs be included in calculations for total ownership costs, to include the fully burdened cost of fuel.

Fuel logistics considerations in wargames. The Services have begun to incorporate additional energy considerations in periodic force planning wargames. These exercises will provide a better understanding of the impact of energy on operations in the mid- to long-term and will help the requirements and acquisition communities to evaluate the operational value of raising energy efficiency requirements of new systems and for refurbishment of legacy systems.

Partnering

The Department is actively seeking opportunities to partner with other federal agencies, industry, academia and the international community to leverage their ongoing efforts in energy. A number of DoD components are working with the Combatant Commanders and the Power Surety Task Force to assess and resolve their energy needs. The DoD is also collaborating with foreign governments to identify areas of commonality to leverage cooperative efforts.

A small portion of Energy Conservation Improvement Program (ECIP) funding is being used to leverage ESTCP funding on facilities energy technologies. In FY 2007, these programs combined to fund four projects: a building integrated photo-

voltaic roof, innovative fast pyrolysis technology, liquid-desiccant outdoor air conditioning, and a micro-turbine power generator. In each of these projects, ECIP funds the construction, and ESTCP funds the monitoring and validation. Technologies that are proven through this process can then be spread throughout the DoD.

Goal 4: Establish Metrics

The final goal focuses on measuring the Department's progress by establishing performance targets and metrics based on quantifiable analysis. These performance measures will help to increase awareness and visibility of energy issues; incentivize, measure and reward progress; and change the Department's culture to value energy appropriately. Collectively, these goals establish the framework for managing energy across the Department.

The installations and environment community has a well-defined series of metrics to monitor energy consumption and the use of alternatives, as outlined in annual reports and scorecards. Examples are included in the sidebar below. The DoD is in the initial stages of considering how to adapt this for platforms.

SUMMARY

The Department has a balanced portfolio of energy efforts in place, either in testing or in the planning stages. Our business and planning processes are being amended to better determine the value of how and how much to reduce energy-related risks, while maintaining or improving capabilities. The Department is developing and testing technologies to manage supply and demand more effectively. The DoD Energy Security Strategic Plan will provide senior leaders with a clear, forward-leaning, and operationally-focused set of options to deliver a much more sustainable, resilient force with greater endurance over the full range of future missions. The Department's strategy recognizes the value of energy and puts us on a path to greater energy security.

NOTES

* JASON is an independent advisory body of highly accomplished scientists and other scholars who self-select endemic issues and challenges facing the Department and attempt to provide actionable solutions.

† Additional examples and details can be found in the Annual Energy Management Report (http://www.acq.osd.mil/ie/irm/Energy/energymgmt_report/fy07/DoD-Narrative-Final.pdf).

‡ O28 is a renewable-based biodiesel formulation consisting of O2Diesel™ and B20 biofuel.

§ Chairman of the Joint Chiefs of Staff Instruction (CJCSI) 3170.01F - Joint Capabilities Integration and Development System (JCIDS) and Chairman of the Joint Chiefs of Staff Manual (CJCSM) 3170.01C Operation of the Joint Capabilities Integration and Development System (JCIDS).

Energy Goals

- Reduce fuel demand → implies annual reduction [National Defense Strategy June 2008]
- Reduce installations energy usage by 30% by 2015 [Executive Order (EO) 13423 / 2007 Energy Act]
- Reduce petroleum consumption for non-tactical vehicles by 20% by FY15 [2007 Energy Act]
- Certify synfuel in all Air Force aircraft by 2011 [Secretary of the Air Force goal]
- 25% of electricity from renewable sources by 2025 [National Defense Authorization Act 2007]
- Reduce fossil fuels in new/renovated buildings: 55% by 2010; 100% by 2030 [2007 Energy Act]
- 30% of hot water in new/renovated buildings from solar by 2015 [2007 Energy Act]
- Increase non-petroleum fuel by 10% per year [EO 13423/2007 Energy Act]
- Energy as selective Key Performance Parameter [Chairman, Joint Chiefs of Staff Instruction 3170.01F/Chairman, Joint Chiefs of Staff Manual 3170.01C]
- Fully burdened cost of energy in tradeoff analyses [USD(AT&L) memo of April 07]
- Energy included in life cycle sustainment metrics for MDAPs [USD(AT&L) memo of July 08]
- Building metering data entered into benchmarking database [2007 Energy Act]
- Electricity metering by October 2012 [2005 Energy Act]
- Natural gas and steam metering by October 2016 [2007 Energy Act]